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GB 1450654 A GB 1266966 A US 5009705 A
US 4950328 A

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INT CL[5] C22C , E21B
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# (54) Improved gage protection for rock bits

(57) A rotary cone drill bit is disclosed as having ultra hard gage maintaining cemented tungsten carbide inserts which are formed from tungsten carbide powder having an average grain size of less than 1.0 micron, preferably in the range of from 0.05 to 0.5 microns cemented with Co, Ni or Fe. Preferably, the carbide is cemented with less than 16 weight percent cobalt. Such inserts have a hardness from 92.5 Rockwell A to 97.0 Rockwell A as compared with less than 92 Rockwell A for previous inserts. These heel row inserts significantly increase the wear resistance of the bit gage surfaces. When used in compression on the gage heel row these inserts will withstand the high impact loads encountered in hard tough rock bit drilling.

Fig. 2

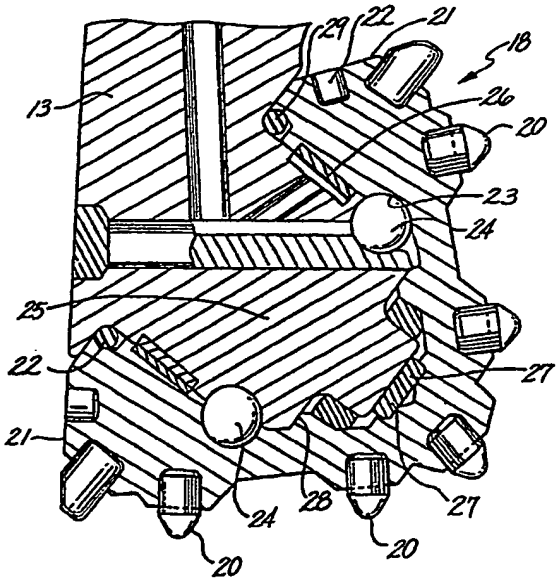


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Fig. 1

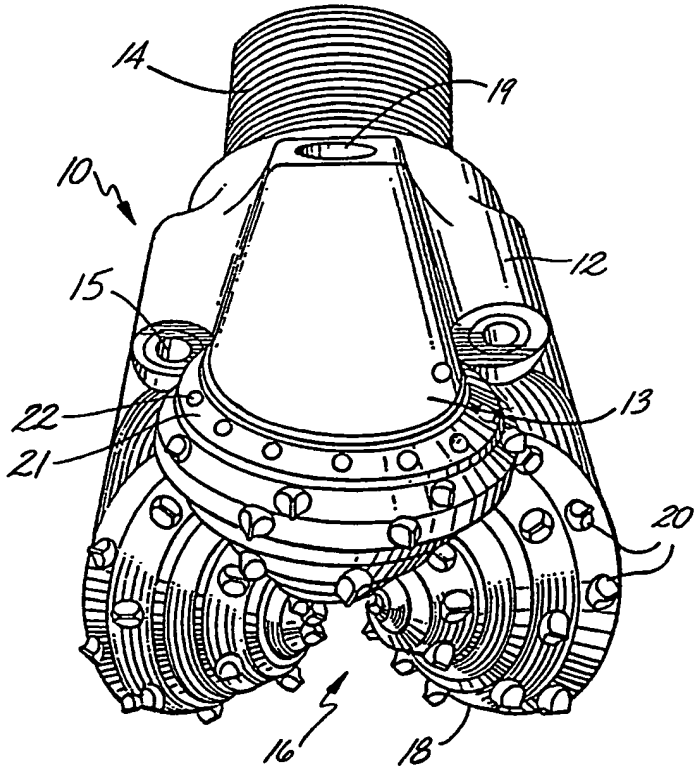
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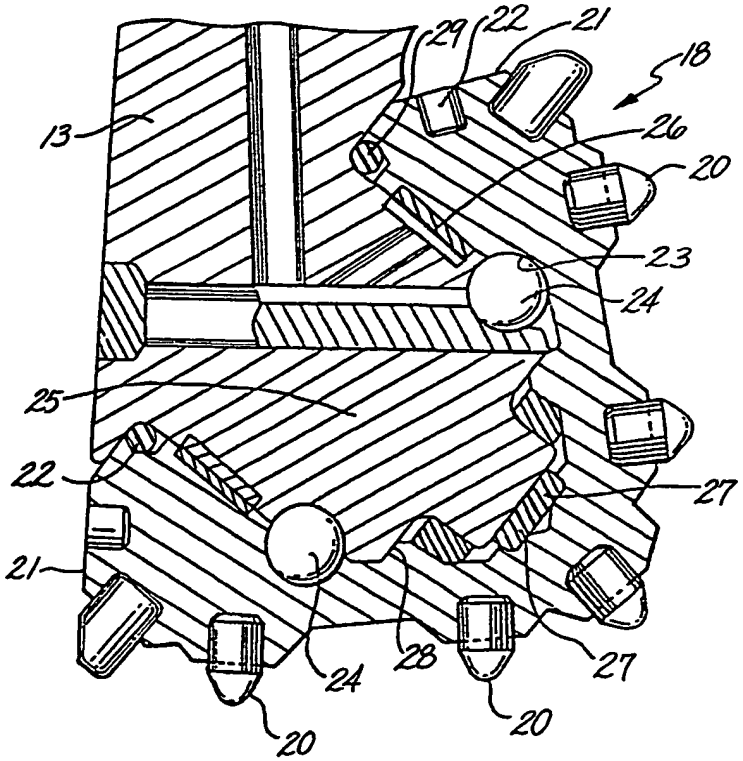
Fig. 2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# IMPROVED GAGE PROTECTION FOR ROCK BITS

The present invention relates to rotary cone rock bits having hard metal cutter inserts positioned on the rotary cones of a rock bit.

More specifically, this invention relates to very hard, wear resistant cemented tungsten carbide inserts fitted particularly on the heel surface of a rotary cone for a rock bit. The heel surface of a cone for a roller cone bit, on which the tungsten carbide inserts are positioned is the only surface on the roller cone that is essentially perpendicular to the borehole bottom and parallel to the bit centerline at the moment of rolling contact of the heel surface with the borehole wall. In the drilling industry, maintenance of the gage circumference of a borehole is essential to prevent pinching of subsequent rock bits as they are lowered into the borehole for continued drilling. If the heel row of inserts of a roller bit becomes worn, the rock bit begins to drill an undersize borehole. Replacement of a worn rock bit with a new bit having a gage diameter that is larger than the gage of the borehole cut by the previous undersize rock bit means that the bit engages the wall of the borehole before it reaches the bottom. Consequently, as the new bit is lowered into the formation it becomes pinched, resulting in either catastrophic failure of the rock bit or

drastically reduced rock bit life.

It is well known in the art to provide hard, wear resistant gage protection on the heel rows of the roller cones of a rock bit. For example, U.S. Patent No. 3,727,705 describes cylindrical tungsten carbide inserts positioned on the gage heel row of a roller bit. This patent shows using standard hard (<92 Rockwell A) carbide heel row inserts positioned at different spacings and diameters on the heel row surface of each roller cone of the drill bit. This provides more dense and broader contact area of the inserts in contact with an abrasive earthen formation wall while drilling. Although this does provide somewhat better gage wear protection, it still has insufficient wear resistance to maintain bit gage diameter when drilling many very hard and abrasive rocks.

U.S. Patent No. 4,940,099 shows using normal hard grade (<92 Rockwell A) tungsten carbide heel row inserts alternating with softer grade tungsten carbide inserts having polycrystalline diamond (PDC) outer wear surfaces. While this arrangement does improve wear resistance of the bit gage surfaces in some applications, PDC insert breakage is still a serious problem because of the high impact loads encountered while drilling extremely hard and tough rock. Polycrystalline diamond is extremely hard but very brittle. Its impact strength is an inverse function of its hardness.

It would be desirable to mitigate premature wear and/or breakage of the gage maintaining heel row cemented carbide inserts of a roller cone rock bit, thereby assuring a full gage well bore.

There is therefore provided in practice of this invention a carbide insert for use in a gage

maintenance row of a rock bit comprising a cemented tungsten carbide powder with an average grain size of less than 1.0 micron. Preferably, this powder has a size range from 0.05 micron to 0.5 micron and a metal binder selected from the group consisting of cobalt, nickel and iron.

The present invention is one relating to rotary drill bits in which tungsten carbide cutting inserts are rigidly affixed in sockets in rotatable cones. Further, a group of inserts in each cone define a heel or gage reaming row. These heel row inserts are made of cemented tungsten carbide having hardness ranging from 92.5 Rockwell A to 97.0 Rockwell A, which is significantly harder than inserts in present use, therefore making them superior for gage wear maintenance of a rock bit roller cone gage surface.

These heel row tungsten carbide inserts also have the toughness to withstand the high drilling impact loads that often fracture the prior art polycrystalline diamond compact heel row inserts.

These and additional features and advantages of this invention will become more fully apparent in the following description when considered in conjunction with the accompanying drawings wherein:

FIGURE 1 is a perspective view showing a roller cutter drill bit that embodies the principles of the invention; and

FIGURE 2 is fragmentary view in longitudinal section of roller cutter drill bit having a rotatable cutter cone supported thereon.

Figure 1 illustrates a rotary cone rock bit 10 fitted with tungsten carbide cutting inserts generally designated as 20. The bit consists of a bit body 12

threaded at a pin end 14 and having a cutting end generally designated as 16. Each leg 13 on the bit body supports a rotary cone 18 rotatably retained on a journal 25 cantilevered from each of the legs (Fig. 2). The tungsten carbide drilling inserts 20 are, for example, rigidly affixed in circumferential rows on each of the rotary cones. Typically, these inserts as well as the heel row inserts 22 are press fitted under compression into insert retention sockets formed in the cones. The heel row gage reaming inserts 22 are rigidly mounted on the outer gage surface 21 of each rotary cone 18. The heel row inserts are essentially flush with the gage surface 21 of the rock bit roller cone 18.

The rock bit 10 further includes a drilling fluid passage through the pin end 14 that communicates with a plenum chamber (not shown) inside the body. Typically one or more nozzles 15 are secured within bit body 12. The nozzles 15 direct drilling fluid from the plenum toward a borehole bottom. The upper portion of each of the legs 13 may have a lubricant reservoir 19 to supply a lubricant to each of the rotary cones 18.

As shown in Figure 2, each rotary cone head section 18 has ball bearings 24 positioned in a raceway 23 to rotatably affix the cone 18 to the journal 25.

Further bearing means are provided, such as the main journal bearing 26, the journal nose thrust button 27 and the journal thrust washer 28. Sealing means, such as an O-ring 29, are used to retain lubricant in the bearings and to exclude contaminants.

A plurality of tungsten carbide drilling inserts 20 are rigidly affixed in circumferential rows on each rotary cone 18. The gage maintaining heel row inserts 22 are rigidly mounted in compression and are normal to and essentially flush with the gage surface 21 to provide gage wear protection and to maintain a full gage well bore.

New technology has now made possible the manufacture and use of tungsten carbide (WC) powders considerably smaller than 1.0 micron, having a size range of 0.05 micron to 0.5 micron. This is many times smaller than the greater than one micron powders currently used in the hardest grade (90.0 Rockwell A to 92.5 Rockwell A) cemented carbide inserts for rock bit gage protection. Using these new ultra fine grained WC powders with appropriate grain growth inhibitors (such as vanadium carbide), and an appropriate binder such as cobalt (less than 16% by weight), ultra hard (92.5 Rockwell A to 97.0 Rockwell A) cemented tungsten carbide inserts can commercially be made. Although tungsten is the preferred carbide former for use in this invention, carbides of all the metals in Group IV A, V A, and VI A of the periodic system, or an alloy thereof, can theoretically be used for this purpose. Also cobalt is the preferred binder metal for use in this invention, but nickel and iron can be used advantageously.

The carbide heel row inserts 22, described above, have the toughness to withstand high impact drilling conditions when used in compression of a press fit heretofore described.

It should be apparent from the foregoing description that the present invention provides significant advantages. When drilling very tough abrasive rock formations these novel carbide gage reaming inserts 22 have the hardness to provide significantly better gage wear protection for a rock bit than do state of the art tungsten carbide gage inserts; thereby greatly extending the useful life of the bit. Under very high impact drilling conditions this invention can withstand much higher impact loads without breakage than do polycrystalline diamond compacts. This also significantly extends the useful life of the bit.

It will of course be realized that various modifications can be made in the design and materials of the present invention without departing from the spirit thereof. Thus while the principal preferred construction and materials of the invention have been explained and illustrated in what is now considered to represent its best embodiments, it should be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

CLAIMS

1. A cemented tungsten carbide insert for use in a rock bit comprising tungsten carbide powder with an average grain size of less than 1.0 micron and a metal binder selected from the group consisting of cobalt, iron and nickel.

2. A rotary cone rock bit comprising:

a bit body;

at least one rotary cutter cone mounted for rotation on the bit body;

a plurality of cemented carbide cutting inserts mounted in the cutter cone; and

a plurality of cemented carbide gage inserts in a gage maintenance row on the cutter cone, such a gage insert comprising a carbide powder with an average grain size of less than 1.0 micron and a metal binder selected from the group consisting of cobalt, iron and nickel, said gage insert having a hardness in the range of from 92.5 Rockwell A to 97.0 Rockwell A.

3. The rotary cone rock bit as set forth in Claim 2 wherein said carbide powder is formed from a metal selected from Groups IV A, V A, VI A of the periodic system or an alloy thereof.

4. The rotary cone rock bit as set forth in either one of Claims 2 or 3 wherein the carbide powder is formed from tungsten.

5. The rotary cone rock bit as set forth in any of the preceding claims wherein the metal binder is cobalt.

6. The rotary cone rock bit as set forth in any of the preceding claims wherein the cobalt content is less than 16 percent by weight.

7. The rotary cone rock bit as set forth in any of the preceding claims wherein the particle size of the carbide is in the range of from 0.05 to 0.5 microns.

8. A method of enhancing the wear resistance and toughness of sintered cemented carbide inserts comprising the steps of;

compacting ultra fine tungsten carbide particles having an average grain size of less than 1.0 micron,

cementing said ultra fine particles with a cobalt metal binder, and

sintering said carbide particles and said metal binder into suitable insert shapes.

9. A cemented tungsten carbide insert for use in a gage maintenance row of a rock bit comprising tungsten carbide powder with an average grain size of less than 1.0 micron and a metal binder of cobalt being less than 16 percent content by weight.

10. The insert as set forth in Claim 9 wherein the carbide insert has a hardness from 92.5 Rockwell A to 97.0 Rockwell A.

11. The insert as set forth in Claim either one of Claims 9 or 10 wherein the particle size of the carbide is in the range of from 0.05 to 0.5 microns.

12. An insert for use in a rock bit substantially as described herein with reference to the accompanying drawings.

**Amendments to the claims have been filed as follows**

1. A rotary cone rock bit comprising:

a bit body;

at least one rotary cutter cone mounted for rotation on the bit body;

a plurality of cemented carbide cutting inserts mounted in the cutter cone; and

a plurality of cemented carbide gage inserts in a gage maintenance row on the cutter cone, such a gage insert comprising a carbide powder with an average grain size of less than 1.0 micron and a metal binder selected from the group consisting of cobalt, iron and nickel, said gage insert having a hardness in the range of from 92.5 Rockwell A to 97.0 Rockwell A.

2. The rotary cone rock bit as set forth in Claim 1 wherein said carbide powder is formed from a metal selected from Groups IV A, V A, VI A of the periodic system or an alloy thereof.

3. The rotary cone rock bit as set forth in either one of Claims 1 or 2 wherein the carbide powder is formed from tungsten.

4. The rotary cone rock bit as set forth in any of the preceding claims wherein the metal binder is cobalt.

5. The rotary cone rock bit as set forth in any of the preceding claims wherein the cobalt content is less than 16 percent by weight.

6. The rotary cone rock bit as set forth in any of the preceding claims wherein the particle size of the carbide is in the range of from 0.05 to 0.5 microns.

7. A method of enhancing the wear resistance and toughness of sintered cemented carbide inserts comprising the steps of;

compacting ultra fine tungsten carbide particles having an average grain size of less than 1.0 micron,

cementing said ultra fine particles with a cobalt metal binder, and

sintering said carbide particles and said metal binder into suitable insert shapes.

8. A cemented tungsten carbide insert for use in a gage maintenance row of a rock bit comprising tungsten carbide powder with an average grain size of less than 1.0 micron and a metal binder of cobalt being less than 16 percent content by weight.

9. The insert as set forth in Claim 8 wherein the carbide insert has a hardness from 92.5 Rockwell A to 97.0 Rockwell A.

10. The insert as set forth in Claim either one of Claims 8 or 9 wherein the particle size of the carbide is in the range of from 0.05 to 0.5 microns.

11. A cemented carbide insert for use in a rock bit comprising carbide powder with an average grain size of less than 1.0 micron and a metal binder selected from the group consisting of cobalt, iron and nickel.

12. A rock bit substantially as described herein with reference to the accompanying drawings.

13. An insert for use in a rock bit substantially as described herein with reference to the accompanying drawings.

| Patents Act 1977<br>Examiner's report to the Comptroller under Section 17<br>(The Search report) | Application number<br>GB 9321726.3 |
|---|---|
| **Relevant Technical Fields**<br><br>(i) UK Cl (Ed.M) C7A<br><br>(ii) Int Cl (Ed.5) C22C | Search Examiner<br>R B LUCK<br><br>Date of completion of Search<br>21 DECEMBER 1993 |
| **Databases** (see below)<br>(i) UK Patent Office collections of GB, EP, WO and US patent specifications.<br><br>(ii) | Documents considered relevant following a search in respect of Claims :-<br>1, 8 and 9 |

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| A | US 5009705 | (MITSUBISHI METAL CORP | 1 at least |
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| Patents Act 1977<br>Examiner's report to the Comptroller under Section 17<br>(The Search report) | Application number<br>GB 9321726.3 |
|---|---|
| **Relevant Technical Fields**<br><br>(i) UK Cl (Ed.M) E1F (FGB, FGC)<br><br>(ii) Int Cl (Ed.5) E21B | Search Examiner<br>R B LUCK<br><br>Date of completion of Search<br>18 MARCH 1994 |
| Databases (see below)<br>(i) UK Patent Office collections of GB, EP, WO and US patent specifications.<br><br>(ii) DERWENT WPI | Documents considered relevant following a search in respect of Claims :-<br>2-7 |

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